

Chapter 11 Landfarming

11-1. General

Landfarming, its requirements, application, and resulting waste streams are discussed in the chapter's first section. The second part of the chapter is a hazard analysis with controls and control points listed.

11-2. Technology Description

a. Landfarming Methods.

Landfarming is a biological remediation technology in which contaminants in soils, sediments, sludges, or soil-like materials are degraded by microorganisms to produce innocuous or stabilized byproducts.

During a landfarm operation, soils, sediments, sludges, or soil-like materials are treated in-situ, and then are applied to a soil surface or excavated and placed on liners to prevent further contamination (Figure 11-1). Populations of indigenous microorganisms are also stimulated to grow and transform the contaminants. The following parameters are usually monitored or controlled:

- Mixing (tilling).
- Leachate collection system (sand or gravel, or both).
- Geomembrane.
- Secondary leachate collection/leak detection layer constructed of sand/gravel.
- Secondary synthetic liner.
- Low permeability compacted clay liner.
- Moisture content (controlled by irrigation or spraying).
- Oxygen level (controlled by tilling the soil or aeration).
- Nutrients (nitrogen and phosphorus are controlled by adding fertilizer, as necessary).
- pH (controlled by adding lime).
- Soil bulking (controlled by blending soil amendments with soil, if necessary).
- Temperature (temperature is usually not controlled, operation is often seasonal).

b. Equipment and Land Requirements.

Landfarming utilizes commercially available farm equipment such as tractors, rotary tillers, chisel plows, soaker hoses, and rotary sprinklers. The nature of the technology is such that it requires substantial open areas to create land treatment units, and these areas must be prepared for proper drainage, equipment access, and materials management.

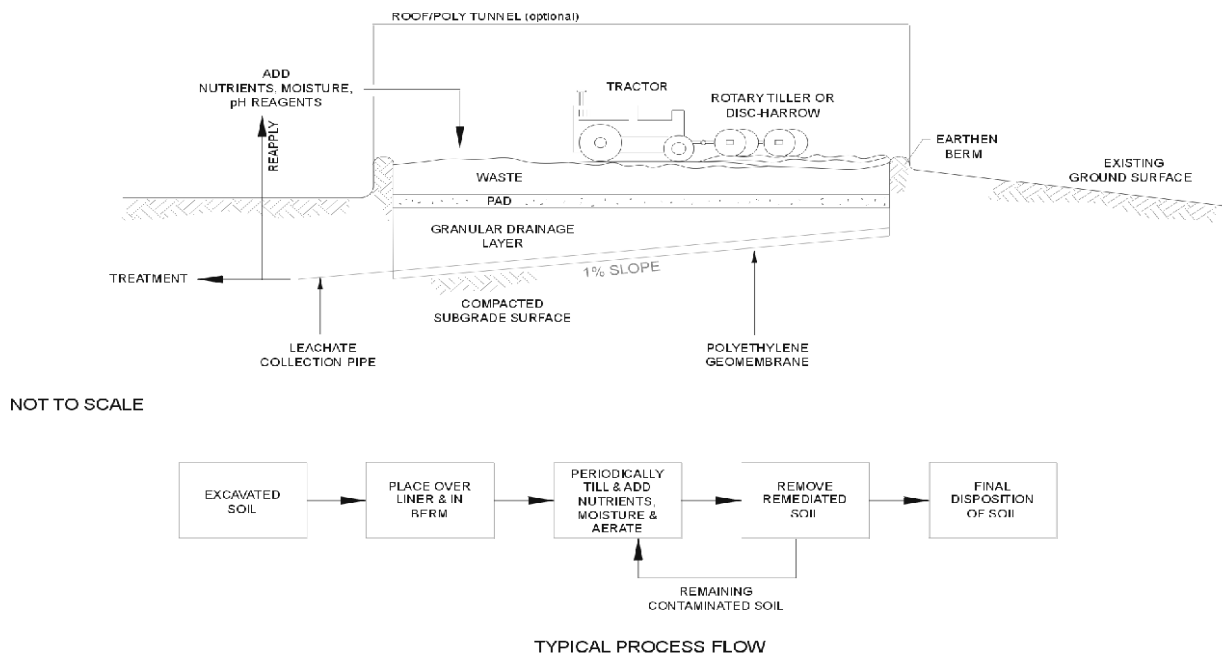


FIGURE 11-1. LANDFARMING

c. Applications.

Land farms have been most successful in treating petroleum hydrocarbons, such as diesel fuel, No. 2 and No. 4 fuel oils, JP-5, oily sludge, wood-preserving wastes (pentachlorophenol, polycyclic aromatic hydrocarbons [PAHs], and creosote), coke wastes, and some pesticides. Landfarm degradation rates decrease with an increase in molecular weight or with an increase in the number of aromatic or cyclic rings (e.g., PAHs). Chlorinated or nitrated compounds are also usually more difficult to degrade than hydrocarbons. Depending on regulatory requirements, treated soil may be backfilled to its original location, left on the land treatment unit, or disposed of off site.

d. Resulting Waste Streams.

Landfarming processes may produce three streams that may require additional handling:

- Wastewater (may require additional treatment).
- Treated soil (or soil-like materials).
- Volatile emissions from soil tilling.

11-3. Hazard Analysis

Principal unique hazards associated with landfarming, methods for control, and control points are described below.

a. *Physical Hazards.*

(1) *Equipment Operation.*

Description. During soil excavation and landfarm construction, workers may be seriously injured or killed by heavy equipment such as tractors, rotary tillers, chisel plows, and rotary sprinklers. Landfarm construction may include the preparation of berms that may be steep and become slippery in wet or rainy conditions.

Control. Controls for equipment hazards include:

- Equip all heavy equipment with backup alarms.
- Provide equipment spotters where beneficial.
- Provide all workers working in the vicinity of the operating heavy equipment with fluorescent orange or lime green traffic vests.
- Approach operating equipment from the front and within view of or direct communication with the operator, preferably making eye contact.
- Do not walk on or near the berms, especially during or after periods of heavy rainfall.
- Train workers in the potential operational hazards and safety features of the heavy equipment.

CONTROL POINT: Construction, Operations, Maintenance

(2) *Wind.*

Description. Installation of landfarm liners and covers in high winds can pose hazards to workers, as blowing liners can trip or knock down workers holding or standing on or beside unsecured liners.

Control. Controls for wind include:

- Install liners on calm days.
- Place soil or sand bags onto the liner to anchor it. The installer should determine the anchoring needs at the time of installation and ensure that anchoring specifications are met or exceeded.

CONTROL POINT: Construction, Maintenance

(3) *Slipping.*

Description. Installation of landfarm liners and covers can pose a slip hazard, particularly when wet. Plastic and wet clay liners can be very slippery, especially when placed on the slopes or for footing.

Control. Controls for slip hazards include:

- Use rope ladders for ascending/descending lined slopes.
- Select appropriate shoe soles for maximum traction.

- Erect barriers or warnings around excessively wet areas of liner.
- Lay high-traction walkways over the liners.
- Carry light loads or use more workers to carry larger single loads.
- Train workers on the liner characteristics that create slipping hazards.

CONTROL POINT: Design, Construction, Operations, Maintenance

(4) *Sharp Liner Edges.*

Description. Synthetic liners are made in varying thickness and rigidities. Some liner edges are sharp and stiff after being cut to shape and can inflict cuts and abrasions.

Control. Controls for sharp liners include:

- Wear long-sleeved shirts, full-length pants, safety boots, and appropriate work gloves (e.g., cut resistant, leather or leather-palmed) for better grip and protection.
- Wear safety glasses or goggles to help prevent eye injuries.
- Workers should position themselves to avoid direct line of contact with sharp liner edges.

CONTROL POINT: Construction, Maintenance

(5) *Heat Stress.*

Description. Heat-related illnesses may occur during liner installations. Because most synthetic liner materials are dark or black to enhance ultraviolet (UV) resistance, they absorb radiant energy and emit considerable heat. The polished surfaces of liner materials can also reflect considerable angled radiant energy, enhancing the energy absorbed by the worker even when under a canopy or wearing a hat. Heat stress that can result in heat exhaustion and heat stroke, can affect workers during operations under conditions that contribute to the heat load. Hot and humid conditions combined with operations, such as liner welding or other heat-producing activities, may further increase the potential for heat-related illnesses.

Control. Controls for heat stress include:

- Vigorously train workers in the signs and symptoms of heat stress.
- Use the Buddy System.
- Provide easy access to water, frequent mandatory breaks, and canopies or other shaded break areas.
- Require the use of sun hats and other protective clothing. Loose clothing and sun hats should not be worn around moving parts or equipment that may snag the worker and draw him or her into a danger zone. Equipment operators may use UV skin barrier cream. All UV skin barrier creams should be pre-approved.
- Monitor for heat stress using the physiological or Wet Bulb Globe Temperature (WBGT) Index protocol provided in the most recent publication of the American Conference of Governmental Industrial Hygienists (ACGIH)

“TLVs and BEIs: Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices.”

CONTROL POINT: Design, Construction, Operations, Maintenance

(6) *Muscle Injuries.*

Description. Manual lifting and moving of large rolls of liner material or weighted anchoring materials may expose workers to lower back and shoulder strain.

Control. A control for muscle strain includes:

- Use mechanical lifting equipment, such as backhoes with cables, and spreaders to lift and move liner material.
- Train the workers in proper load handling using heavy lifting machinery and in personal lifting techniques. Utilize more than one worker and the buddy system including spotters in managing the loads.

CONTROL POINT: Construction, Operations, Maintenance

(7) *Burns.*

Description. Burn hazards to the skin may exist with different types of operating equipment, including a liner extrusion welder and generators.

Control. Controls for burn hazards include:

- Train all personnel using or exposed to hot operating equipment during liner installation in hazards associated with the equipment.
- Guard all exposed, heated surfaces to prevent accidental contact.
- Prepare procedures for the safe operation, repair, and maintenance of equipment and include a testing procedure for determining safe temperature.
- Use insulated gloves with gauntlets, coveralls, and face protection appropriate for eliminating the hazard.

CONTROL POINT: Construction, Maintenance

(8) *Moving Equipment.*

Description. Landfarm units may require periodic aeration by mechanically turning over soils with heavy equipment, such as tractors equipped with mixing equipment, rototillers, plows, discs, and tillers. Other devices, such as a “scarab”-type device, may throw debris during the turning process. Pre-screening or sizing equipment, such as grinders, shakers, and screeners may pose hazards if unguarded. Body parts or loose clothing may become entangled in pulleys, drive shafts, and other moving equipment.

Control. Controls for moving equipment include:

- Keep clear of operating equipment and approach only when within view of the operator.
- Guard all moving or rotating equipment to prevent accidental contact.

- Operate the system with the machine guards in place.
- Prohibit the use of loose clothing around equipment.
- Train workers in the hazards and safety features of operating the heavy equipment.

CONTROL POINT: Construction, Operations, Maintenance

(9) *Puncture Hazards.*

Description. Workers may be exposed to puncture and cut hazards to feet and hands from rough or jagged waste materials during landfarming operations.

Control. Controls for puncture hazards include:

- Wear safety boots with steel shanks and puncture resistant soles.
- Minimize manual handling of waste material.
- Wear puncture and cut-resistant gloves if contact with waste materials is necessary.
- Train workers in unique material handling hazards associated with landfarming waste materials.

CONTROL POINT: Construction, Operations, Maintenance

(10) *Trip Hazards.*

Description. Trip hazards may exist with hoses and piping systems used for irrigation of the landfarm.

Control. Controls for trip hazards include:

- Exercise caution when walking over hoses and pipes.
- Use extra lighting if necessary to ensure adequately illuminated walkways.
- Train workers in potential trip hazards associated with the waste material.

CONTROL POINT: Design, Maintenance

(11) *Respirable Quartz.*

Description. Depending on soil types, exposure to respirable quartz may be a hazard. Consult geologists to confirm the presence of a respirable quartz hazard (e.g., to determine if soil types are likely to be rich in respirable quartz). As an aid in determining respirable quartz exposure potential, sample and analyze site soils for fines content by ASTM D422 (R2002): "Standard Test Method for Particle Size Analysis of Soils" followed by analysis of the fines by X-ray diffraction to determine crystalline silica quartz content.

Control. Controls for respirable quartz include:

- Wet the soil periodically with water or amended water to minimize worker exposure. Consult 29 CFR 1910.1000, Table Z-3, to calculate acceptable respirable dust concentrations based on percent silica in the quartz.

- Use respiratory protection, such as an air-purifying respirator equipped with N, R, or P100 particulate air filters.
- Train workers in the hazards of crystalline silica inhalation exposures.

CONTROL POINT: Construction, Operations

(12) *Electrocution.*

Description. Workers may be exposed to electrocution hazards when working around electrical utilities such as overhead power lines.

Control. Controls for electrocution include:

- Locate overhead power lines, either existing or proposed, in the pre-design phase.
- Keep all lifting equipment, such as cranes, forklifts, and drilling rigs, at least 10 feet from a power line according to Occupational Safety and Health Administration (OSHA) regulation 29 CFR 1926.550 and EM 385-1-1, Section 11.

CONTROL POINT: Design, Construction, Operations

(13) *Equipment Operation (Slopes).*

Description. Equipment used to move soil and liner materials on steep slopes may roll over, seriously injuring or killing the operator.

Control. Controls for equipment use on slopes include:

- Design the angle of the slope to minimize the potential for roll-over.
- Maintain safe operating conditions for equipment during construction.
- Use equipment with roll-over protective devices (ROPS).
- Do not operate equipment on excessively steep slopes or unstable ground.
- Wear seat belts during operation.
- Train workers in the potential operational hazards and safety features of the heavy equipment.

CONTROL POINT: Design, Construction, Operations

(14) *Traffic Hazards.*

Description. During the implementation of field activities, equipment and workers may come close to traffic. Equipment may also need to cross public roads. The general public may be exposed to traffic hazards during loading and transporting soil.

Control. Controls for traffic hazards include:

- Post warning signs according to the criteria of the “Department of Transportation Manual on Uniform Traffic Devices for Streets and Highways.”
- Provide traffic guides with fluorescent orange or lime green safety traffic vests.

- Develop a traffic management plan before remediation activities commence to help prevent accidents involving site equipment. EM 385-1-1, Section 21, provides plan details.

CONTROL POINT: Design, Construction, Operations

(15) *Emergency Wash Equipment.*

Description. Emergency shower/eye wash equipment required per 29 CFR 1910.151 is not always provided with adequate floor drains, thereby creating potential electrical hazards and walking surface hazards during required testing and use.

Control. A control for emergency wash equipment includes:

- See American National Standards Institute ANSI Z 358.1 – 1998: “Emergency Eyewash and Shower Equipment” for design requirements.
- Equip showers/eye wash equipment with accompanying functional drains to isolate and collect the shower/eye washwater from unprotected electrical equipment and walking surfaces that, when wet, create slipping and electrical hazards.

(16) *Design Field Activities.*

Description. Design field activities associated with subsequent construction may include surveying, biological surveys, soil gas surveys, geophysical surveys, trenching, drilling, stockpiling, contaminated groundwater sampling, and other activities. Each of these field activities may expose the survey personnel to physical, chemical, radiological, and biological hazards.

Control. Controls for hazards resulting from design field activities include:

- Prepare an activity hazard analysis for predesign field survey activities. EM 385-1-1, Section 1.A, provides guidance on developing an activity hazard analysis.
- Train workers in hazards identified.

CONTROL POINT: Design

b. Chemical Hazards

(1) *Vapors and Solvents.*

Description. Heating or cementing cover and liner materials may generate vapors, either from the cement applied, thermal decomposition, or both; from off-gassing of liner material components, such as plasticizers (e.g., phthalate esters, adipate esters); or from the solvents contained in the cementing agent (e.g., methyl ethyl ketone, methylene chloride). A vapor inhalation hazard may exist to workers during liner installation. A dermal hazard may also exist from skin

contact with the cementing chemicals or waste materials generated during installation.

Control. Controls for hazardous vapors and solvents include:

- Ventilate the area or use appropriate respirators to control exposures during installation.
- Select respirator cartridges (e.g., organic vapor cartridges) based on consultations with the liner manufacturers and the potential compounds that may be emitted.
- Use personal protective equipment (PPE) such as chemically inert gloves (e.g., nitrile for many petroleum distillates) to help control dermal exposure.
- Analyze work tasks and potential for chemical exposure to determine the correct PPE or respirator cartridges if necessary. The analysis should include a chemical profile on the liner or cementing agents to ensure appropriate equipment.
- Train the workers in the chemical inhalation and contact hazards of the cementing materials and thermal decomposition properties of the liners.

CONTROL POINT: Construction, Maintenance

(2) *Contaminants.*

Description. Workers can be exposed to contaminants of concern and chemical reagents. The addition of urea or other ammonia-based fertilizers may result in worker exposure to ammonia. Intermediate degradation products, resulting from breakdown of contaminants of concern, may also represent exposure hazards. Exposure may occur via inhalation/ingestion/dermal contact routes during loading, unloading, preprocessing, tilling, turning, and other landfarming processes where soils are agitated.

Control. Controls for chemical contaminants include:

- Use PPE (e.g., butyl rubber gloves for exposure to nitrogen compounds) to control dermal exposure during urea and nitrogenous fertilizer additions.
- Analyze work tasks and potential for chemical exposure to determine the correct PPE or respirator cartridges, if needed. The analysis should include obtaining specific chemical hazard information to ensure appropriate PPE.
- Use respiratory protection including the use of an air-purifying respirator equipped with N, R or P95 particulate air filters or appropriate chemical or organic vapor cartridges.
- Train the workers in the unique chemical hazards and hazard controls of the contaminants of concern.

CONTROL POINT: Operations

(3) *Enclosed Land Treatment Facilities.*

Description. If the land treatment unit facilities are enclosed or tented, workers entering the landfarm may be entering a confined space and require respiratory protection.

Control. Controls for enclosed treatment facilities include:

- Test the atmosphere within the enclosure or tent frequently to ensure a safe atmosphere.
- Design both natural or mechanical ventilation into the enclosed space, as appropriate to reduce the buildup of noxious or toxic interiors.
- Develop and implement a confined-space entry program if the testing indicates atmospheric contaminants or oxygen depletion (see 29 CFR 1910.146).

CONTROL POINT: Design, Operations

(4) *Acid/Base Hazards.*

Description. Workers may be exposed to chemical burn hazards while handling acids and bases used for pH control. Some materials used in landfarming may pose explosion hazards if contact is made with other incompatible materials (e.g., ammonium nitrate and fuels). Others may be hygroscopic, which may result in chemical reactions.

Control. Controls for acidic or caustic chemicals include:

- Train workers in the chemistry involved in the landfarm system design and operation, in the heat of reaction of the chemical reactions, or in handling the reactive materials and landfarm chemical additives.
- Train operators in emergency procedures in case of a catastrophic event, in life saving first aid procedures including halting and neutralizing chemical reactions, extracting, decontaminating and stabilizing victims, and in emergency isolation procedures.
- Minimize contact with acidic or corrosive chemical materials by using mechanical chemical delivery methods.
- Wear gloves (e.g., nitrile) and other PPE that is resistant to the materials handled including eye and face protection.
- Segregate chemical reagents used in landfarming to prevent accidental mixing of reactive chemicals, especially ammonium nitrate fertilizers and fuels.

CONTROL POINT: Design, Operations

c. *Radiological Hazards.*

No unique hazards are identified.

d. *Biological Hazards.*

(1) *Pathogenic Microbes.*

Description. Landfarm activities can expose workers via inhalation/ingestion/dermal contact to pathogenic microbes. The hazard may increase during dry and windy periods when microbe-entrained dusts become airborne from soil agitation, aerators, or wind. Exposure can occur during installation of

the landfarm liner or during agitation of the waste material. Inhalation of pathogenic microbes may cause allergic reactions or illness.

Control. Controls for pathogenic microbes include:

- Apply water periodically to limit airborne dust and exposure.
- Use PPE such as rubber gloves to help prevent dermal exposure to microorganisms.
- Use respiratory protection such as an air-purifying respirator with N, R or P100 or N, R or P95 particulate air filters approved for protection against microbial hazards during dusty periods.
- Train the workers in pathogenic hazards found in the media being treated by the landfarming activities.

CONTROL POINT: Construction, Operations

(2) *Pests.*

Description. Workers may be exposed to a wide array of biological hazards, including snakes, bees, wasps, ticks, hornets, and rodents during any phase of remediation. The symptoms of exposure vary from mild irritation to anaphylactic shock and death. Deer ticks may cause Lyme disease. Rodents can transmit Hanta virus. Mosquitoes can transmit the West Nile Virus.

Control. Controls for pests include:

- Periodically inspect the site to identify bee hives and wasp nests and to check for snakes and rodents.
- Use professional exterminating companies if necessary.
- Use tick and insect repellents containing the active ingredient, N,N-diethyl-m-toluamide (DEET) 25% for exposure control. Clothing may be treated with permethrin clothing repellent BEFORE donning, for added protection. Workers should check their skin and clothing for ticks periodically.
- Train the workers in the biota presenting hazards in the areas of potential contact.

CONTROL POINT: Construction, Operations, Maintenance